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By Emilio CARVALHO TAVARES de MATTOS,
Chief of Concession Section,
and Vice-Director
of the Water Division, D.N.P.M.,
of the Ministry of Mines and Energy,

Oscar de PAULA BERNARDES,
Ildeu RAMOS de LIMA,
and Hugo MELZER
Engineers,
Brasil

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EMILIO CARVALHO TAVARES DE MATTOS
Chief of Concession Section, and Vice-Director of the Water Division, D.N.P.M., of the Ministry of Mines and Energy

OSCAR DE PAULA BERNARDES, ILDEU RAMOS DE LIMA AND HUGO MELZER,
Engineers, Brazil

I - INTRODUCTION:

1. Abundant national and foreign research and documentation concerning babassu vegetation and its energetic value dates from 1820 and 1922 respectively, and refers to the immense areas of Brazil covered by dense natural palm vegetation of Orbignya Speciosa, Attalea eleifera etc. in the tropical North, North-East and Interior from Amazonas to Maranhão, and as far south as Espírito Santo and Minas Gerais in the subtropical and moderate zones. This native vege - tation is, however, mostly concentrated in the States of Maranhão, Piauí and Goiás.
2. A comparison with the areas of most intense electrification in the Center-South and along the coast up to the State of Rio de Janeiro shows in a striking way that approximately the 2/3 of the national territory and the half of the Brazilian population that up to now do not enjoy the benefits of electrification are situated mostly in the areas occupied by babassu palm vegetation and by a poor, starving population needing regular jobs and better living standard.
3. About a thousand conventional babassu oil extracting industries, large and small, with subsidiary soap, candle and cosmetic manufacture employing 60,000 families of these palm weed areas,(1), are still completely dependent on primitive collecting and breaking of the hard nuts with an ax for a low income of some 50 US dollars per family a year, losing in this way some 94 percent of the nuts'weight unexploited, though it has already been shown experimentally that the other parts of the nut,besides the oil-containing kernels, are good raw material for economic production of numerous by-products.
4. The areas of largest babassu palm vegetation in the States of Maranhão, Piauí and northern Goiás only were estimated (2)(3) at some 100,000 km2 with some 80 (4) to 160 (5) productive palm trees per hectare, depending on whether additional pasture, rice or other cultures are planted among the palm trees or not. The dense native forest, e.g. in Maranhão, contain up to 3000 palms per hectare and have therefore to be cleared to assure rational production.
5. Selected and cleared palm vegetation is, according to several practical experiments, capable of large-scale industrialization.

This would include, besides the conventional oil extraction with subsidiary industries, the production of additional alimentary and industrial products, residual coke, steam, gas and electri energy sufficient for industrial consumption, as well as residential and rural electrification and eventual local siderurgical uses.

6. The development of such large-scale industrialization programs could elevate the relatively stagnant conventional comestible babassu oil production progressively from year to year, contributing with the numerous possible by-products of this integral babassu industrialization to the necessary diversification of Brazil's economy, to the elevation of living standards in under-developed areas, as well as to a solution of the world food problem.

II - MECHANIZATION AND RE-ORIENTATION OF MANUAL WORK

7. For the reasons mentioned in paragraph 1, complete mechanization, so far as possible, of palm wood clearing, nut harvesting, transport and drying methods (to a great part already practically experimented (6)), as well as automatic breaking of the nuts and separation of the parts and their further industrial refining (1)(6) are to be carried out on a larger, semi-industrial scale. It must be large enough for experimentation with destructive distillation of coke, gas and power, production, and steam and hot water production by heat recuperation, so as to obtain conclusive results for large-scale industrial installations able to produce an essential increase not only in the production of oil and new comestible and industrial by-products, but also in the agricultural and energetical uses and, in the eventual presence of local mineral deposits, also in siderurgical production.

8. The considerable amount of human manual work liberated by the mechanization of the nut breaking has to be reorientated by instruction and training to amplify wood clearing and nut harvesting, facilitated by easier access to the productive palm trees. To accelerate the palm wood clearing the young and still unproductive palm trees may, so far as possible, be torn down by small caterpillar tractors, provision being made for immediate carrying away of the eliminated small palm vegetation to avoid proliferation of insects.

9. This material should, from the beginning, serve for the production of comestible medulla ("palmito") for man and beast and the large quantities of palm leaves of these "unproductive" palms for local paper pulp when economically possible, and for paper manufacture.

10. The latter, where possible, could be an excellent solution for the problem of local manufacture of the necessary large quantities of sacks for the transport of the residual material from the kernels after oil extraction, which is a good commercial cake ("torta") for feeding animals or for production of fertilizing material.

11. Though the "mechanized" wood clearing mentioned in II (8) will require supplementary manual work for cutting and leading, it is obvious that the larger part of the manual labor freed from the traditional nut breaking by ax will be available for nut harvesting. Therefore a larger quantity of harvested nuts in comparison to the traditional method of harvesting and nut breaking by the same person may be expected, especially if easier access to adult productive palm trees is provided.

12. The mechanical separation of epicarp and mesocarp, and subsequent breaking of the hard woodlike endocarp and separation of the kernels, as well as of the comestible vitamin and starch-containing flower from

the mesocarp fibres, and of the tannin from the comestible flower has been tried out already on a semi-industrial scale, proving that the transportation of the whole nuts to the factory is economically justified only when other by-products also, and not only the comestible oil, are produced.

13. In this respect it is important to note that, according to analyses (2) of the total weight of the babassu nut, e.g., from Maranhão, there is: 15% epicarp, 20% mesocarp, 59% endocarp and only 6% oil-containing kernels, the only part up to now generally made use of. The interest in technological use also of the other components of the nut is consequently obvious.

14. It is suggested that the fibrous epicarp be experimentally used for pastebeard manufacture for local carton fabrication, for the transportation of manufactured material.

15. The mesocarp is of special interest because of its composition: 8,7% humidity, 0,7% oil, 66,2% starch, 0,9% tannin, 22,3% short fine fibres, 1,2% mineral matter. The whole nut contains more than 13,2% of starches against only 3,7% of oil conventionally utilized. In the technological process already experimentally used, 5% of the starch could be transformed, after tannin separation, into an alimentary fleur of original, agreeable taste ("Palmelate"), 10% remaining for forage and some 5% adherent to the fibrous parts, which could, eventually, be used for production of ethyl alcohol, butyl alcohol, acetone etc.

III. ENERGY PRODUCTION:

16. In paragraph II 13) we have seen that the hard, woodlike endocarp is some 59% of the whole weight of the babassu nut. With 6% for the kernels, 94% of the total weight of the nut remains for the shell as a whole, if not separated into its components by rather complicated technological processes. According to the more or less refined technology chosen, 50 to 94% of the total weight of the fruit will serve as fuel for gas, power and eventual residual coke, tar and hydrocarbon production. Therefore the babassu nut may be considered essentially as a fuel,(1) notwithstanding its importance as a source of high quality comestible and nutritive substances.

17. In spite of the evident economic limits, the best technological process for energy use of the babassu nut, with special regard to the peculiar Brazilian lack of good coal and present insufficient national petrolproduction, which covers only some 1/3 of consumption, seems to be the destructive distillation of the endocarp in industries of sufficient capacity, say some 400 to 4000 tons of whole babassu nuts per day, to guarantee an economic return on the complicated preliminary process of the separation of the shell into its components, as well to be able to use modern gas turbines of current reliable construction, which range from about 3,000 to 30,000 kW, corresponding to a daily production of about 60 to 600 thousand m3 of distillation gas of some 3,400 kcal/m3 and to an average efficiency of only 12,5% for turbines without heat recuperation from the exhaust combustion gases. The latter would, however, be indispensable in industries of this order of capacity, raising the overall efficiency to some 65 to 70% and yielding additional power production from the heat recuperation steam boilers, serving also diverse industrial processes.

18. The destructive distillation of 1 ton of the previously separated endocarp gives, on the average, about 351 kg of gas of some 3400 kcal/kg, 280 kg of an excellent coke of some 7800 kcal/kg, 50 kg of tar of 9000 kcal/kg, 3,8 kg of methyl-alcohol of 8500 kcal/kg as combustible components. So far as the residual coke is not used locally, e.g., in producer gas generators for vehicles, boats, locomotives etc., it may, as has already been tried out, be briquetted with its own tar so as to be economically transported to other places of consumption.

19. To avoid accumulation of the large quantities of ashes from the destructive distillation, it is suggested that they be pressed together with residual fibrous material into bricks for local civil engineering construction uses.

20. It is clear that it would be extremely hazardous to instal industries on the order of capacity referred to in paragraph III 17) without previous research on a smaller scale, particularly of the use of the "babassu-gas", still unknown as to its practical behavior, exception being made for some sporadic experimentation. The average composition of the gas from 25 experimental distillations at 900 to 1100° C during the relatively short time of some 3 hours, on the average, was:

CO_2	O_2	C_nH_m	CO	CH_4	H_2	N_2
20,8	1,0	2,8	22,6	18,3	16,8	17,7 % of total weight.

The high content, 22,6%, of CO may demand absolute tightness in operation for toxicity of this gas component, and also normal operation of the prime movers cannot be guaranteed without practical experimentation.

21. Furthermore it must be remembered that the bulk of the existing babassu oil industries are far below the capacity referred to in III 17). This facilitates the development of smaller industrial "micro-power stations" with excessing energy, to be successively interconnected by an electrical high tension transmission system.

22. Therefore it appears indispensable to instal an experimental, integral pilot babassu industry with a capacity of some 100 to 150 tons of whole babassu nuts per day, in order to be able to experiment with gas turbines of current construction, as well as modern reciprocating gas engines of various types, suitable also for smaller babassu industries, which cannot afford the expensive installation of reterts, accessories and gas-holders, as well as the complex technology of complete integral babassu processing, and must content themselves with the complete gasification of the whole nut shells in simple suction producer-gas generators. In order to be able to yield experimental results for the numerous smaller babassu industries, the gas-electric pilot power station should therefore be equipped, besides the destructive distillation plant, also with two or more producer-gas generators and reciprocating gas engines, suitable for relatively poor gas.

23. The transportation of the large quantities of nuts and industrial products would require for the trucks very much gasoline or Diesel oil, which is expensive, especially when transported to distant industrial sites. The use of the nut shells, of the separated endocarp or of the residual coke from dry distillation, in modern perfected gasogenes, mounted on the trucks, will assure independence

from expensive motor fuel.
24. Since reciprocating gas engines work with essentially higher temperatures than current gas turbines, the smaller babassu industries can be operated with reasonable efficiency by reciprocating gas engines with some 40 to 150 HP, using poor gas down to about 1500 kcal/Nm3. Using rich babassu distillation gas of some 3400 kcal/Nm3, modern piston gas engines up to 6000 HP, 600 r.p.m. could be tested in a pilot industry, as mentioned under III 22). The reciprocating gas engines reach gas temperatures up to about the double of some 720° C, admitted for gas turbines and thermal efficiencies up to 30 % and more, whereas gas turbines, e.g. of 2900 to 5800 kW show efficiencies of only some 15,4 to 18,8% respectively. This is the consequence of the limitation of gas admission temperatures for gas turbines, constructed today for petroleum derivates and natural gas of very high thermal values that cause vanadium corrosion at higher gas temperatures. Also construction material difficulties limit an essential raising of the gas temperatures. Therefore, at the actual stage of current gas turbine construction, gas turbines suitable for babassu distillation gas, with its rather modest thermal value are available only from 2900 kW upwards. Such gas turbines, which result in a considerable economy of space, could be also tried out in the gas-electric pilot power station. On the other hand, the piston gas engines are of more robust construction and will have less pre-compression extra-losses. For both types of these gas prime movers the over-all thermal efficiency can be raised by exhaust gas heat recuperation to some 70%.
25. The gas prime movers generally need pre-compression of the used gas, representing supplementary energy loss. The latter can be avoided or reduced by the use of modern producer-gas generators under pressure e.g. of the type "Lurgi", which permit not only the production of rich and light liquid hydrocarbones, but also the transportation of the produced gas economically to larger consumption centers at distances up to some 150 km. These possibilities begin approximately at a yearly production capacity of 4 to 14 million m3 of gas, (7) according to local conditions.
26. In fact we are very likely to find such favourable conditions in the areas of richest babassu vegetation. As an example we would mention, e.g., the partly installed experimental pilot station for integral industrialization in Quelru, some 105 km from São Luiz, Capital of the State Maranhão, as a large industrial and residential consumption center, and some 160 km in the opposite direction from Cedó, an industrial center with iron, ore and gypsum, anhydride and limestone deposits. This experimental pilot industry could be relatively easily completed by the necessary equipment for general experimentation of all the most convenient uses of babassu palm products, including all the alternatives of energy production, in order to get a solid basis for further development of perfected installation and operation of these industries.

IV - SIDERURGICAL APPLICATIONS:

27. The separation of metallic iron from its minerals requires the presence of a reducing agent in peculiar conditions and quantity. This agent is carbon in one of its commercially available forms, or carbon monoxide (CO).

28. Lack of good metallurgical and siderurgical coke requires a search for substitutes. The residual coke from destructive distillation of babassu nut shells, the endocarp, is a very pure coke with some (1) 4 to 5% of ash, and up to 0,033% of phosphorus and >0,033% of phosphorous and 0,066% of sulphur, the latter remaining always below the corresponding content of coke from the best imported coal, whereas the phosphorus content was found often quite variable according to local soil conditions.

29. The only disadvantages of coke from babassu shells for general siderurgical use are its relatively low mechanical resistance and generally small dimensions. It has, however, been found very suitable for electrical and other furnaces, where high purity and reactiveness and not mechanical resistance are necessary. So with the modern tendency to smaller furnaces without large mechanical stresses the applicability of babassu coke may increase. On the other hand physiochemical briquetting without melting of the agglutinating matter may also make possible wider application of this excellent reducing agent.

30. It has recently been observed that for reduction of ferrous minerals direct contact of the latter with solid carbon may be replaced without inconvenience by contact with CO-gas, produced either within or outside of the furnace. The latter method serves in a more economical and less complex way to form the "fusion beds" for present blast furnaces. A new Brazilian process under experimentation (8) produces, outside the furnace, abundant quantities of carbon monoxide to realize at sufficient temperatures the classical chemical procedure in complete analogy with that used in the reducing zones of conventional blast furnaces. The new Brazilian process provides also for enriching of the reducing gas by hydrogen, by means of recycling of the gas, which becomes synthetic with triple reducing properties.

31. In this way, when smaller local deposits of ferrous minerals, which do not justify transportation of the mineral to large centralized siderurgical plants, are available, small siderurgical plants may be combined with local integral babassu industrialization, by using its residual coke or the reducing gases produced, which if necessary, can be transported at higher pressure even to longer distances with smaller losses than the solid residual coke. The presence of small deposits of ferrous minerals in the areas of densest babassu vegetation justifies the hope of the possibility of such realizations in the near future.

V. RESEARCH, DEMONSTRATION AND TRAINING CENTER FOR BABASSU UTILIZATION:

32. To assure use on an industrial scale of tested processing, creation is suggested of a specialized "Research, Demonstration and Training Center for Babassu Utilization" (9) for applied research by testing and improving methods for palmwood clearing, harvesting and processing of babassu nuts and by-products, including destructive distillation and gasification of the shells and use of the gas produced, e.g., for power production and siderurgical processing.

33. This "Center" should be installed in a convenient babassu palm vegetation area, near or not too far from residential sites and local ferrous mineral deposits, assuring adequate immediate or future gas or power consumption to the gas and power plants to be installed in the "Center", to achieve, so far as possible, complete practical

semi-industrial results, applicable to future large industries of this type, including also the energetical and siderurgical research.
34. Successful methods and equipment would be demonstrated to all interested parties, especially to delegates and workers of the existing babassu oil industries, and suitable candidates would be trained in the tested, improved processing methods.
35. So far as possible, existing or available national equipment should be used. So far as necessary also, foreign equipment, experts and fellowships for suitable Brazilian technicians should be provided, and eventual foreign experts should be assisted by national counter - parts.

VI. CONCLUSION

36. With the purpose of stimulating exploitation of potential local gas, power and mineral reserves and to channelize them towards other industrial, rural and residential consumption centers with a broad view to future interconnection and interchange possibilities, bearing in mind the economic view point for Brazil as a whole and also the local endeavours reflected in various proposed laws, already published in the Official Journal of the National Congress, and to assure dynamic collaboration of all the other Authorities also competent for the exploitation of these very large vegetable oil and energy reserves of the world, the Concession Section of the Ministry of Mines and Energy suggests, in execution of Presidential and Ministerial recommendations, the creation of an Energy Working Group for Integral Babassu Industrialization in order to provide all the necessary steps for Governmental participation and supervision of the project by a centralized organization, assuring the active cooperation of all interested Ministries and Federal and Governmental and other interested Authorities, in order to achieve a modern and efficient exploitation of babassu as an important national fuel for gas, power (10) and mineral, as well as siderurgical, production.

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